Aquatic Invertebrates and Habitat of Tongue and Powder River Drainages

October 15-18, 2002

By: Wease Bollman

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A report to

The Montana Department of Environmental Quality
Helena, Montana

by

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INTRODUCTION

Benthic assemblages are aptly applied to aquatic bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

Multimetric approaches to bioassessment use attributes of the assemblage in an integrated way to measure biotic integrity, defined by Karr and Dudley (1981) as "...the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitats within a region." The additive multimetric approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1996). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998a). The first element is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied must be done, to assist in the interpretation of metric outcomes.

This report summarizes data collected October 15-18, 2002 from the Tongue and Powder River drainages, by means of a multimetric method, an adaptation of the U.S. EPA's Rapid Bioassessment Protocols (RBP III) (Plafkin et al. 1989). Invertebrates were collected at seven sites located in the Northwestern Great Plains ecoregion (Woods et al. 1999). The purpose of the study is to provide information that may be pertinent to the development of pollution control plans or Total Maximal Daily Loads as mandated by the Clean Water Act.

Metric selection for this study is based on the recommendations found in the standard operating procedures for aquatic invertebrate sampling and analysis of the Montana Department of Environmental Quality (Montana DEQ) (Bukantis 1998). Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat parameters and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Assurance of the validity of association between habitat parameters and biotic metrics is particularly compelling in the Plains ecoregion, since impairment of the biotic health of streams in this region is generally the result of non-point sources. Agricultural activities, including cattle grazing and flow alteration, are predominant causes of stream degradation. The benthic assemblages of the Plains ecoregions and the performance of bioassessment metrics have not yet been examined thoroughly enough to determine whether or not the individual metrics or their integrated scores can discriminate impaired conditions from good biotic health. Thus, conclusions concerning bioassessment based upon these metrics must be regarded as tentative.

METHODS

Aquatic invertebrates were sampled by personnel of Montana DEQ from four sites in the Tongue River drainage and three sites in the Powder River drainage from October 15-18, 2002. At three sites, targeted riffles as well as reachwide composite

samples were taken. Sampling site designations and locations are listed in Table 1. The site selection and sampling method employed were based on those developed for the US EPA's Environmental Monitoring and Assessment Program (EMAP). The resulting invertebrate samples were delivered to Rhithron Associates, Inc. for processing, taxonomic determinations, and data analysis. Habitat assessment information was not available.

Table 1. Sample designations and locations. Tongue and Powder River drainages October 15-18, 2002. GPS information was not available.

Site Name	Sample Type	Collection Date	Stream Name
Tongue River drainage			
HWC-2-1 R	Reachwide Composite	10-15-02	Hanging Woman Creek
OC-41-1 R	Reachwide Composite	10-17-02	Otter Creek
TR-1-1 R	Reachwide Composite	10-15-02	Tongue River
TR-1-1 T	Targeted Riffle	10-15-02	Tongue River
TR-13-1 R	Reachwide Composite	10-18-02	Tongue River
TR-13-1 T	Targeted Riffle	10-18-02	Tongue River
Powder River drainage			
LP-3-2 R	Reachwide Composite	10-16-02	Little Powder River
PR-4-1 R	Reachwide Composite	10-16-02	Powder River
PR-5-1 R	Reachwide Composite	10-18-02	Powder River
PR-5-1 T	Targeted Riffle	10-18-02	Powder River

At Rhithron, sample processing proceeded in accordance with EMAP guidelines (Klemm and Lazorchak 1994). Subsamples of at least 500 organisms, based on random full-grid sorts from Caton subsampling devices were obtained, when possible. When an entire sample contained fewer than 500 organisms, the entire sample was sorted. Sorting quality assurance procedures were performed, and a sorting efficiency of about 100% was achieved for the project. Invertebrates were identified to the lowest practical taxonomic level consistent with EMAP protocols. Taxonomic quality assurance consisted of exchange of 100% of samples between professional taxonomists for verification of identifications. The accuracy of taxonomy was assessed at 100% (full agreement between taxonomists). Other quality assurance procedures demonstrated 100% accuracy of data entry (no data entry errors).

For Plains ecoregion sites, community structure, function, and sensitivity to impact were characterized for each subsample using a battery of ten attributes, or metrics, recommended by Bukantis (1998). Actual metric values from each sample were compared to ecoregional reference values to obtain scores. The bioassessment metric battery and metric reference values are given in Table 2. Scores for all metrics were combined, and a total bioassessment score was calculated as a percentage of the maximum possible score. For all sites, the total bioassessment score was expressed in terms of use-support. Criteria for use-support designations were developed by Montana

DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

Table 2. Provisional metrics and scoring criteria for the Montana Plains ecoregions. (Bukantis 1998).

	Score			
Metric	**3**	**2**	**1**	**0**
Taxa richness	>24	24 - 18	18 – 12	<12
EPT richness	>8	8 – 6	5 – 3	<3
Biotic Index	<5	5 – 6	6 – 7	>7
% Dominant taxon	<30	30 – 45	45 – 60	>60
% Collectors	<60	60 – 80	80 – 95	>95
% EPT	>50	50 – 30	30 – 10	<10
Shannon H (log2)	>3.0	3.0 – 2.4	2.4 – 1.8	<1.8
% Scrapers + shredders	>30	30 – 15	15 – 3	<3
# Predator taxa	>5	4 – 5	3 – 4	<3
% Multivoltine	<40	40 – 60	60 – 80	>80

Table 3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis 1998).

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).

% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

RESULTS

Bioassessment

Tables 4a and 4b itemize each contributing metric and show individual metric scores for each site. Figure 1 summarizes bioassessment scores for aquatic invertebrate communities sampled at the 7 sites in this study. Tables 3a and 3b above show criteria for use-support categories recommended by Montana DEQ (Bukantis 1998) and impairment classifications (Plafkin et al. 1989). Invertebrate taxa lists, metric results and other information for each sample are given in the Appendix.

When this bioassessment method is applied to these data, scores suggest that, among the sites in the Tongue River drainage, the site on Hanging Woman Creek was partly supportive of designated uses and moderately impaired. The site on Otter Creek was slightly impaired and partly supportive of uses. Site TR-1-1 on the Tongue River was slightly impaired and partly supportive of uses;: the reachwide composite and targeted riffle samples produced the same classification and use support designation. At Site TR-13-1, the two sample types produced strikingly different bioassessment results: the reachwide composite sample score suggested slight impairment and full use support, while the targeted riffle sample score indicated moderate impairment and only partial use support.

In the Powder River drainage, the site on the Little Powder River was slightly impaired and partly supported designated uses. The reachwide composite sample at Site PR-4-1 on the Powder River was slightly impaired and fully supportive of uses. Site PR-5-1 was moderately impaired and partially supportive of uses; the reachwide composite and targeted riffle samples collected at this site yielded identical total scores.

Aquatic invertebrate communities

Interpretations of biotic integrity in this report are made without reference to results of habitat assessments, or any other information about the sites or watersheds that may have accompanied the invertebrate samples. Interpretations are based entirely on: the taxonomic and functional composition of the sampled invertebrate assemblages; the sensitivities, tolerances, physiology, and habitus information for individual taxa gleaned from the writer's research; the published literature, and other expert sources; and the performance of bioassessment metrics, described earlier in the report, which have been demonstrated to be useful tools for interpreting potential implications of benthic invertebrate assemblage composition.

The Tongue River drainage

The collected organisms from the targeted riffle on Hanging Woman Creek (HWC-2-1) suggests a dysfunctional assemblage; the sample was overwhelmed (71% of organisms) by maggots in the family Ceratopogonidae and pupae in the family Ephydridae. Both dipteran families are generally very tolerant, and their abundance in this sample suggests warm water temperatures and stagnant flow conditions. Information related to habitat is obscured by the dominance of these animals.

At Site OC-41-1, a targeted riffle on Otter Creek, the biotic index value (7.54) and the large component of midges suggests nutrient enrichment. Sixty percent of the midges present in the sample were hemoglobin-bearing animals. Their abundance may be related to hypoxic conditions in soft sediments. Warm water, lentic flow regimes, and nutrient enrichment can contribute to the potential for such conditions. The presence of macrophytes is suggested by the presence of *Caenis* sp. and *Callibaetis* sp., and by the amphipod *Hyalella* sp.

On the Tongue River, a reachwide composite and a targeted riffle were sampled at Site TR-1-1. Both samples produced nearly identical, relatively low biotic index values (4.52 from the riffle, 4.55 from the composite). These results, along with the rich mayfly fauna at this location, suggest that water quality was good. The fauna included many taxa that prefer warm water temperatures; among these were the caddisflies *Helicopsyche borealis* and *Cheumatopsyche* sp., and the mayflies *Choroterpes* sp. and *Tricorythodes minutus*. Groundwater may have influenced water quality; turbellarians

were abundant at the site. Eleven "clinger" taxa and a rich caddisfly fauna imply that stony substrates free of fine sediment deposition were available for colonization here. Other habitat types also appeared to be diverse, since overall taxa richness was high, and the number of predator taxa was notable.

The two sample types gave varying bioassessment scores and results at the other Tongue River site sampled (Site TR-13-1). Water quality indicators in the data gave results that were difficult to interpret. Although mayflies were not abundant in either sample, the mayfly fauna was fairly rich. However, biotic index values calculated for both samples were confounded by the overwhelming dominance of the tubificid oligochaete *Limnodrilus* sp. in the targeted riffle sample and *Tricorythodes minutus* in the reachwide composite sample. The reachwide composite sample contained a richer fauna (34 taxa) than the targeted riffle sample (23 taxa); this was noted to be a common characteristic of these two sample types in another study of Eastern Montana streams (Bollman 2003). Also noted in that study was evidence that reachwide composite samples appear to be more informative; perhaps they give a more accurate assessment as well. In the composite sample taken at this site, dipterans, including chironomids, accounted for 63% of collected organisms. Many midges were hemoglobin-bearers, suggesting that hypoxic substrates were present at the site. Warm water temperatures and mild nutrient enrichment are consistent with these findings. The presence of the midge *Camptocladius* sp. suggests that cattle had access to the sampled site. However, both the functional mix and the taxonomic composition of the sampled assemblage reveal a diverse invertebrate assemblage characteristic of a Plains ecoregion stream.

The Powder River drainage

Invertebrates were apparently not abundant at the sampled site on the Little Powder River (LP-3-2), where the entire reachwide composite sample yielded only 247 animals. The assemblage included quite tolerant animals; the biotic index value (6.25) was elevated relative to expectations for a Plains stream. Hemoglobin-bearing midges were common among the chironomid fauna, suggesting that soft, hypoxic substrates were present. These findings implicate warm water temperatures and nutrient enrichment. Only four "clinger" taxa were collected; fine sediments may have been the predominant substrate component. The prevalence of the elmid *Dubiraphia* sp. among the collected organisms suggests that macrophytes added to habitat complexity at this site.

The reachwide composite sample taken on the Powder River at Site PR-4-1 contained only 300 organisms in the entire sample. Still, taxa richness was only slightly depressed compared to expectations for a 500 organism sample from this ecoregion. This suggests that habitats were quite diverse. Four mayfly taxa were present, and the biotic index value (5.67) calculated for the assemblage was within expectations. Water quality was probably good at this site, and was likely not excessively impaired by nutrient enrichment. The sampled assemblage was well-balanced among taxa and functional groups. The presence of at least eight "clinger" taxa suggests that clean stony substrates without sediment contamination were available. The taeniopterigid stonefly, which was common in the sample, was likely the plains genus *Oemopteryx fosketti*. Its presence may indicate that reach-scale habitats were largely intact here.

Similar bioassessment results were obtained from both the reachwide composite sample and the targeted riffle sample taken at Site PR-5-1 on the Powder River. Neither sample yielded an abundance of organisms, however; the riffle sample was especially depauperate. Taxonomic and functional composition of both samples was very similar. The blackfly *Simulium* sp. and the hydropsychid caddisfly *Cheumatopsyche* sp. dominated both samples; and *Simulium* sp. overwhelmed the assemblage collected in the reachwide composite. Dominance of filter-feeding taxa such as these suggests that suspended particles of fine organic material were a major energy source for the invertebrate assemblage here. One-third of the taxa in both samples were "clingers"; thus some hard substrates free of fine sediment deposition appear to have been available for colonization. Small sample sizes and overwhelming dominance renders the biotic index value unreliable.

CONCLUSIONS

- The sampled assemblage from Hanging Woman Creek suggests a dysfunctional system characterized by stagnant warm water.
- Warm water, lentic flow conditions, and nutrient enrichment appear to characterize the sampled site on Otter Creek.
- Good water quality and diverse unimpaired habitats are suggested by the invertebrate assemblage collected at Site TR-1-1on the Tongue River. At Site TR-13-1, the sampled assemblage appears to be characteristic of a functional Plains river community. Perhaps mild nutrient enrichment is indicated by the taxonomic composition of the sample.
- Warm water temperatures, nutrient enrichment, and soft sediments appear to characterize the sampled site on the Little Powder River.
- The Powder River at Site PR-4-1 supported an invertebrate assemblage that suggests good water quality and intact instream habitats. Organisms were not abundant at Site PR-5-1, and samples were overwhelmed with filter-feeders, which suggests abundant organic particles in suspension.

Table4a. Bioassessment metrics and scores for four sites in the Tongue River drainage. October 15-18, 2002. Montana plains ecoregions reference (Bukantis 1998).

	HWC-2-1	OC-41-1	TR-1-1		TR-13-1	
VALUES	**R**	**R**	**R**	**T**	**R**	**T**
Taxa richness	9	24	32	30	34	23
EPT richness	0	3	15	11	7	5
Biotic Index	6.10	7.54	4.52	4.55	6.41	8.83
% dominant taxon	71.12	21.25	65.97	59.78	15.49	70.10
% collectors	27.86	66.22	81.33	81.38	38.22	79.38
% EPT	0	5.31	78.18	76.37	17.46	2.75
Shannon diversity	1.33	3.21	1.96	2.14	3.55	1.24
% Scrapers + shredders	0	6.64	6.28	6.57	14.66	2.06
# Predator taxa	3	6	6	6	11	5
% Multivoltine	8.17	44.40	14.31	19.44	39.58	5.24
SCORES						
Taxa richness	0	2	3	3	3	2
EPT richness	0	0	3	3	2	1
Biotic Index	1	0	3	3	1	0
% dominant taxon	0	3	0	1	3	0
% collectors	3	2	1	1	3	2
% EPT	0	0	3	3	1	0
Shannon diversity	0	3	1	1	3	0
% Scrapers + shredders	0	1	1	1	1	0
# Predator taxa	1	3	3	3	3	2
% Multivoltine	3	2	3	3	3	3
TOTAL SCORE	8	16	21	22	23	10
PERCENT MAXIMUM	**26.66**	**53.33**	**70**	**73.33**	**76.66**	**33.33**
IMPAIRMENT CLASSIFICATION[1]	**MOD**	**SLI**	**SLI**	**SLI**	**SLI**	**MOD**
USE SUPPORT[1]	**PART**	**PART**	**PART**	**PART**	**FULL**	**PART**

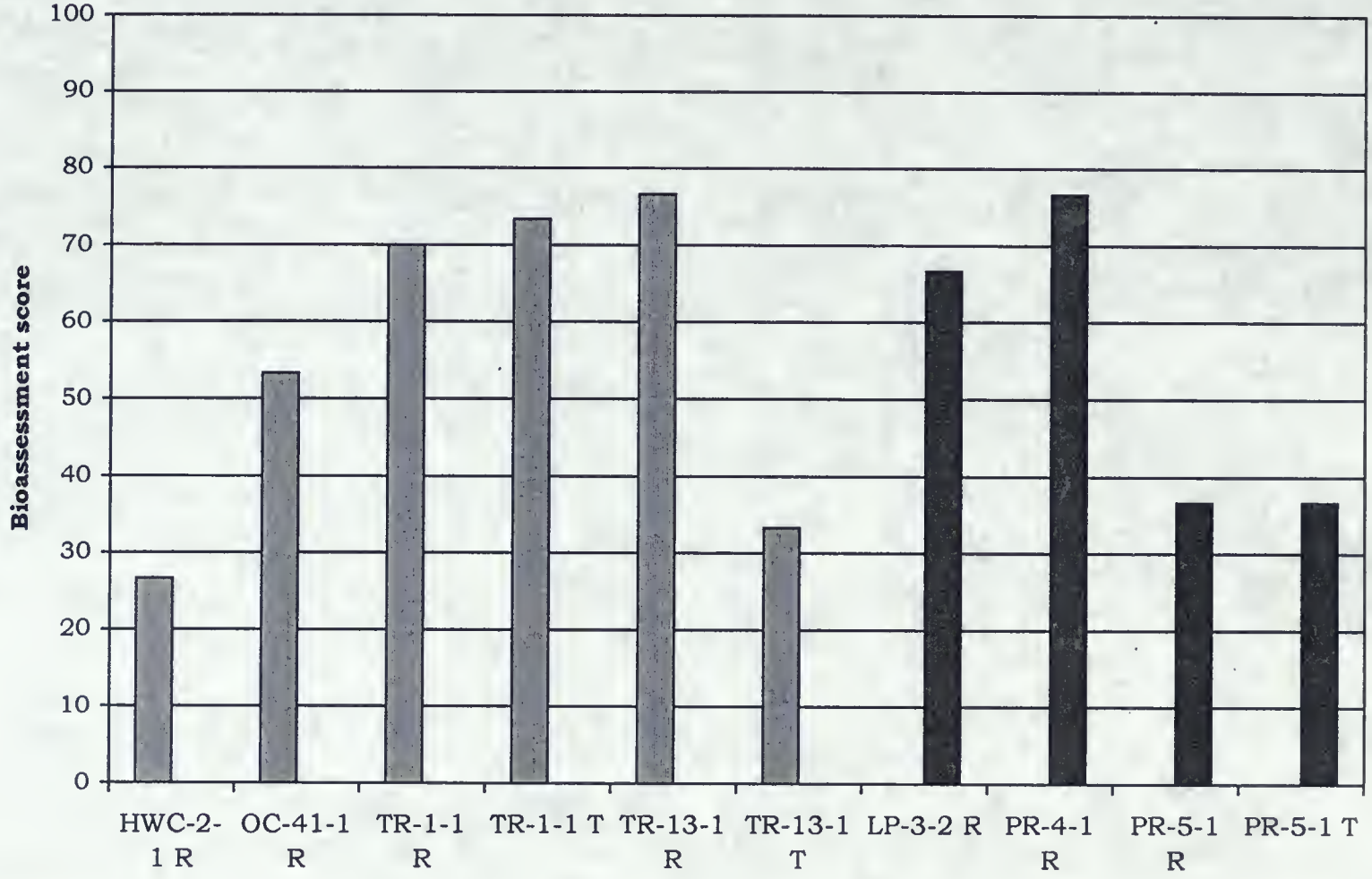
[1]See Table 3b for impairment classification criteria and Table 3a for use support criteria.

Table4b. Bioassessment metrics and scores for three sites in the Powder River drainage, 2002. Montana plains ecoregions reference (Bukantis 1998).

	LP-3-2	PR-4-1	PR-5-1	
VALUES	**R**	**R**	**R**	**T**
Taxa richness	28	23	12	10
EPT richness	4	7	4	3
Biotic Index	6.25	5.67	4.94	5.28
% dominant taxon	26.32	16.67	86.54	51.72
% collectors	58.30	50.00	95.00	82.76
% EPT	5.26	32.67	10.00	24.14
Shannon diversity	3.00	3.16	0.39	2.34
% Scrapers + shredders	4.45	10.33	3.46	8.62
# Predator taxa	9	6	1	2
% Multivoltine	13.36	26.25	2.79	13.36
SCORES				
Taxa richness	3	2	1	0
EPT richness	1	2	1	1
Biotic Index	1	2	3	2
% dominant taxon	3	3	0	1
% collectors	3	3	1	1
% EPT	0	1	1	1
Shannon diversity	2	3	0	1
% Scrapers + shredders	1	1	1	1
# Predator taxa	3	3	0	0
% Multivoltine	3	3	3	3
TOTAL SCORE	20	23	11	11
PERCENT MAXIMUM	**66.66**	**76.66**	**36.66**	**36.66**
IMPAIRMENT CLASSIFICATION[1]	**SLI**	**SLI**	**MOD**	**MOD**
USE SUPPORT[1]	**PART**	**FULL**	**PART**	**PART**

[1]See Table 3b for impairment classification criteria and Table 3a for use support criteria.

Figure 2. Total bioassessment scores compared among sites in the Tongue and Powder River drainages, Oct 15-18, 2002. The revised bioassessment method (Bollman 1998a) was used to determine scores for Site 1; Montana DEQ Plains ecoregions reference criteria (Bukantis 1998) were used to determine scores for Site 2 and Site 3. Scores are reported as the percent of maximum possible score.



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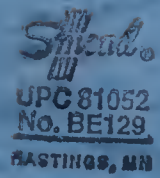
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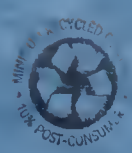


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